# 5.—REVISION OF THE EMBIOPTERA OF WESTERN AUSTRALIA.

By Consett Davis, M.Sc.
Lecturer in Biology, New England University College, Armidale, N.S.W.

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## INTRODUCTION.

The Order Embioptera is well represented in Western Australia, somewhat sporadie collecting having to date revealed five species, of whieh three are endemie and rather bizarre in structure. Interesting collections have been received from time to time from the Western Australian Museum, by courtesy of the Curator, Mr. L. Glauert, to whom my thanks are due. It is the purpose of this paper to collate the systematie reeords relating to those species known from Western Australia, and to add certain new loeality records. It is hoped that this may lead to further colleeting, which would almost eertainly result in the diseovery of new forms.

## GENERAL ORGANISATION.

The Embioptera form a small but distinet Order of Orthopteroid inseets, showing some affinity to the Isoptera and to a less extent the Dermaptera and Perlaria, from all of which, however, they are probably separated by a long line of independent ancestry. No distinetly deseriptive common name has been applied to these insects; the name "Foot-spinners" is here proposed, referring to the distinctive habit of members of the Order of spinning silken webs from the glands of the fore tarsi.

Apart from the Palaeozoic Sub-Order Protembioptera, with two monotypic genera (*Protembia* Till., *Tillyardembia* Zal.) of ill-defined structure, the Order is represented by about 140 Tertiary and Reeent species, distributed through some 36 genera and seven families, of which two are represented in Western Australia, each by a single genus.

The females of Tertiary and Reeent genera (Sub-Order Euembioptera) are wingless and larviform, and possess no good taxonomie charaeters. The males are usually winged, oeeasionally wingless, while a few speeies are known within which both forms oeeur. The two pairs of wings are equal and widely-spaeed, and the veins are rather weak. A short subcosta is present; the radius ($R_1$) is the strongest vein in the wing, its sector arising near the base and forking a little before half the length of the wing to an anterior branch ($R_{2+3}$), usually fusing with $R_1$ subterminally, and a posterior branch ($R_{4+5}$), whieh may be forked or, as in all Australian species, simple. The media (M) arises separately near the radial sector; it is rarely forked, usually simple, and often only weakly developed. The first eubital ($Cu_1$) has a strong main axis and an anterior branch ($Cu_{1a}$), usually weak, but forked onee or several times in some exotie genera; there is no seeond eubital. One small anal vein is present. Cross-veins may be frequent, but their number and position shows individual variation, and they are of no taxonomie signifieance.

The tarsi of all legs are three-segmented. The first segment of the fore tarsi is greatly inflated, housing the spinning-glands, which discharge by hollow setae on the plantar surface. The second legs are weakly developed. The hind femora are always greatly swollen, housing the enlarged depressor tibiae muscles by whose contraction the insect is able to dart backwards very rapidly. The first two segments of the hind tarsus have their plantar surfaces variously beset with vesicles and stiff setae, these being important systematic characters.

The male terminalia, the most important taxonomic criteria, are best understood by reference to the larval form, with which the adult female agrees essentially except in the presence of a transverse genital aperture on the posterior part of the eighth abdominal sternite. In the larva, the ninth abdominal tergite is transverse, the tenth subtriangular. The ninth abdominal sternite is subquadrate, the tenth divided by a median longitudinal cleft to two triangular hemisternites. Between these and the bases of the cerci are subannular sclerites referred to as cercus-basipodites. These are very probably paraprocts, although American workers (*e.g.*, Snodgrass, 1935, Fig. 140F) refer to the structures here interpreted as hemisternites of the tenth segment as paraprocts. Only a study of the late embryological stages can finally decide this point, which is, however, unimportant in the internal classification of the Order. The cerci are two-segmented, each segment smooth and subcylindrical, the basal one thicker.

In all species except *Clothoda nobilis* (Gerst.) (Amazon region), the tenth abdominal tergite of the male becomes cleft at the last ecdysis, although frequently not to the base, so that two more or less distinct hemitergites are formed ; these are furnished with copulatory processes. The right cercus is usually little modified at the last ecdysis, but the first segment of the left cercus is often greatly changed, usually becoming clavate and often developing echinulation on the inner surface. The second segment may remain unchanged or, as in some Australian and North American genera, may be partly or wholly resorbed into the first to form a compound structure.

The ninth abdominal sternite sends out a distal process, which can indeed be detected during the two previous instars in an incipient condition. This process may possibly be equivalent to fused gonocoxites, so that the whole structure may be regarded as a hypandrium. Dorsal to this process is the male genital aperture, usually situated among ill-defined membraneous structures. The right hemisternite of the tenth abdominal segment, and the right cercus-basipodite, usually in part degenerate, sometimes remaining as small sclerites unimportant functionally and taxonomically. The left hemisternite and cercus-basipodite may remain distinct in the adult and develop processes, but more frequently they appear to form a composite structure, often with one or more processes, and usually referred to simply as the left cercus-basipodite.

The male terminalia are in some species probably the most complex in the Class Insecta, the processes of the hemitergites, hypandrium, cerci, and left cercus-basipodite all assisting in holding the unspecialised female terminalia during copulation.

Members of the Order feed predominantly on dead vegetable matter, more particularly bark and fallen leaves. Branching cylindrical tunnels of silk are spun among the food material by means of the tarsal glands, and in these the insects live, being gregarious and subsocial, the female guarding the eggs and young larvae in an enlargement of the gallery. Most of the Western Australian records represent winged males, taken either at light or swarming under weather conditions such as induce this phenomenon in Termites. Search

for the actual colonies may reveal wingless forms of the adult male in species where at present the winged form alone is known, or even new species entirely wingless in all stages, such as in the Eastern Australian genus *Metoligotoma*.

## SYSTEMATICS.

### Family **OLIGOTOMIDAE** Enderlein 1909.

Zool. Anz., 35, p. 190. Type genus, *Oligotoma* Westwood, 1837, *Trans. Linn. Soc.* London, Zool., **17**, p. 373.

In addition to the type genus, whose diagnosis is given below, this family includes only the genus *Haplocembia* Verhoeff (Shores of Mediterranean and Black Seas), which differs from *Oligotoma* in having the males always, instead of exceptionally, wingless, and in the presence in both sexes of a medial bladder or vesicle on the plantar surface of the first segment of the hind tarsus.

### Genus **OLIGOTOMA** Westwood 1837.

*Loc. cit.* (as subgenus of *Embia* Latreille, 1829). Raised to generic rank, Burmeister, 1839, Handbuch der Entomologie, Bd. 2, p. 770.

*Males* winged (more rarely, winged and wingless forms occur within the same species), $R_{4+5}$, M, and $Cu_{1a}$ simple and subobsolescent (each represented by little more than a median row of macrotrichia in a broad band of pigment, Plate 1, Fig. 1); tenth abdominal tergite partly divided to hemitergites, the cleft not extending forward to the ninth tergite; right hemitergite with outer margin produced back as a slender sclerotized lobe, basally overlying an inner membraneous flap, the latter sclerotized only medially, this sclerotization continuous with that of the outer process. Left hemitergite with a prominent process, sometimes complex. First segment of left cercus subcylindrical to clavate but never echinulate; second segment, and both segments of right cercus, elongate-subcylindrical and distinct. Structures at the base of the left cercus, conventionally referred to as the left cercus-basipodite, often complex, and probably always including elements of the left half of the tenth sternite of the larva.

*Both sexes* with plantar surface of first segment of hind tarsus carrying only the terminal bladder, remainder of surface carrying many stiff setae (Plate 1., fig. 2).

The genus is indigenous in the warmer parts of Asia, throughout Australia, in the islands between Asia and Australia, and islands in the Indian Ocean. It is now tropicopolitan, spread by man.

### **Oligotoma glauerti** Tillyard, 1923 (Plate I., figs. 5–7).

*Journ. Proc. Roy. Soc. West Aust.*, **9**, 1, p. 64. Re-described from type series, Davis, 1936, p. 242, Plate I., figs. 6, 13, 20, 27, and 34.

♂ *Length* 9.5–10.0 mm.; head 1.4–1.5 mm., x 1.1 mm.; forewing 8.2 mm., X 2.2 mm.; hindwing 7.5 mm., x 2.2 mm. *Colour* mid-brown, eyes black, wings with veins or their traces bordered by pale-brown bands. *Head* rounded behind; eyes subreniform; antennae with up to 21 segments, maximum total length 7.5 mm.; mandibles (Plate I., fig. 7) slender, left with three thin inwardly-directed teeth terminally and subterminally, right with two; inner margin of left mandible with a median dorsi-ventrally flattened cutting edge. *Thorax*, including wings and legs, normal for the genus. *Terminalia* (Plate I., fig 5) with outer process of right hemitergite ending in two closely-approximated subacute teeth; process of left hemitergite (Plate I., fig. 6) ending in an anchor-shaped hooklet. First segment of left cercus irregularly

melanized, distally curved inwards to a tapered obtuse beak. Ninth abdominal sternite tapered, distally smoothly truneate, margin minutely echinulate distally and on the right. Left cercus-basipodite obtuse, curved upwards and inwards and slightly spathulate. Terminalia otherwise as throughout the genus.

♀ unknown.

*Locality* : Milly Milly Station, Murchison River, 26/v/22, coll. L. Glauert (holotype ♂, W.A. Museum ; paratype ♂, Macleay Museum, Sydney University).

**Oligotoma tillyardi** Davis, 1936 (Plate I., figs. 8–10).

*Proc. Linn. Soc. N.S.W.*, **61**, 5–6, p. 241, Figs. 5, 12, 19, 26, 33.

♂ *Length* 7.4–9.7 mm. ; head 1.3–1.5 mm., x 1.0–1.2 mm. ; forewing 7.5–8.5 mm., x 1.9–2.0 mm. ; hindwing 6.1–7.2 mm., x 1.9–2.0 mm. *Colour* yellowish-brown, eyes and wings as in *O. glauerti*. *Head* as in *O. glauerti*, antennae with up to 19 segments, maximum total length 4.6 mm. Dentition of mandibles (Plate I., fig. 10) resembling *O. glauerti*. *Thorax* including wings and legs normal for the genus. *Terminalia* (Plate I., fig. 8) with posterior process of right hemitergite as in *O. glauerti* ; process of left hemitergite (Plate I., fig. 9) forcipate, right-hand lobe heavily selerotized, curved to the left and acute terminally, left-hand lobe more dorsal in position, flat, less heavily sclerotized, obtuse, curved downwards and to the right terminally and excavate on the concave inner side. First segment of left cercus terminally incurved to form a spathulate process. Ninth abdominal sternite tapered, rather sharply truncate, emarginate latero-distally on the left, margin echinulate distally and on right as in preceding species. Left cereus-basipodite slender, tapered, sub-obtuse distally, fixed to left-hand margin of ninth sternite by membrane. Terminalia otherwise as throughout genus.

♀ unknown.

*Localities* : Morgan's, near Mt. Margaret, x/33 (holotype ♂, Macleay Museum ; paratype ♂♂, W.A. Museum, etc.) ; Belele Station, Murchison (4 ♂♂) ; Annean Station, near Nannine, Murchison (1 ♂). (Last two, new records.)

**Oligotoma approximans** Davis, 1938 (Plate I., figs. 1–2, 11–13).

*Proc. Linn. Soc. N.S.W.*, **63**, 3–4, p. 252, Figs. 116–119.

♂ *Length* 6.3–6.9 mm. ; head 1.0–1.1 mm., x 0.9 mm. ; forewing 5.8–7.2 mm., x 1.5–1.7 mm. ; hindwing 4.8–5.9 mm., x 1.4–1.7 mm. *Colour* dark brown, eyes and wings as in *O. glauerti*. *Head* as in *O. glauerti* ; antennae with up to 18 segments, maximum total length 3.5 mm. ; mandibles (Plate I., fig. 13) of same general form as in preceding species, somewhat stouter. *Thorax* including wings (Plate I., fig. 1) and legs (Plate I., fig. 2, hind tarsus) normal for the genus. *Terminalia* (Plate I., fig. 11) with outer process of right hemitergite slender, tapered, obtuse, and slightly outcurved terminally ; process of left hemitergite (Plate I., fig. 12) basally sinuous, distally slenderly tapered, with a flat subtriangular spine arising half-way along the left-hand margin and directed to the left. First segment of left cereus with a small blunt inner lobe about one-third of length from extremity, inner margin basad to lobe concave. Ninth abdominal sternite tapered posteriorly, distally obliquely truncate and slightly emarginate, concavity filled by a projecting membrane. Left cercus-basipodite as in *O. tillyardi*. Terminalia otherwise as throughout the genus.

♀ unknown.

*Locality :* Fremantle, 20–23/v/35, coll. K. R. Norris (holotype ♂ and paratype ♂, Macleay Museum).

*Note.*—The three foregoing species are probably the most highly-specialised in the genus, agreeing well with the concept that greater structural change is to be expected in those descendants which have migrated furthest from the ancestral region. They may later be separated as two distinct subgenera, one containing *O. glauerti*, the second the other two species.

**Oligotoma gurneyi spinulosa** Davis, 1936 (Plate I., figs. 14–16).

*Op. cit.*, p. 239, Fig. 3.

♂ *Length* 8.7–13.8 mm. ; head 1.7–2.3 mm., x 1.4–2.0 mm. ; forewing 7.0–10.0 mm., x 1.6–2.5 mm. ; hindwing 6.0–9.0 mm., x 1.7–2.5 mm. *Colour* as in *O. glauerti* or somewhat darker. *Head* as in preceding species, eyes prominent ; antennae with up to 20 segments, maximum total length 4.2 mm. ; mandibles (Plate I., fig. 16) essentially as in the preceding species except for the presence of a marked excavation in the proximal half of the inner margin. *Thorax* including wings and legs normal for the genus. *Terminalia* (Plate I., fig. 14) with outer process of right hemitergite terminating in two approximated subacute teeth, the outer one slightly incurved ; process of left hemitergite (Plate I., fig. 15) slender, sinuous, with a slender acute terminal spine directed forward and to the left. First segment of left cercus with a blunt subterminal inward projection, the inner margin basad to this slightly and smoothly concave. (This structure is distorted in the slide mount of the holotype, Plate I., fig. 14 ; for natural structure see Davis, 1936, Fig. 3, $LC_1$.) Ninth abdominal sternite tapered posteriorly and terminally smoothly rounded, right-hand margin sinuous. Left cercus-basipodite intimately fused to the left-hand margin of the ninth sternite, subterminally produced to the left as a sharp spine. Terminalia otherwise as throughout the genus.

♀ See below.

*Localities :* Morgan's, near Mt. Margaret, x/33 (holotype ♂, Macleay Museum ; paratype ♂♂, W.A. Museum, etc.) ; Lake Violet, East Murchison District, x/27 (1 ♂) ; Geraldton (1 ♂) ; and the following new records : Belele Station, Murchison (3 ♂♂) ; Annean Station, near Nannine, Murchison (8 ♂♂, in association with 1 ♂ of *O. tillyardi*, and a female, length 14 mm., colour dark red-brown, and therefore probably referable to *O. gurneyi spinulosa* but larviform and with no apparent specific characters).

**Oligotoma gurneyi** Frogg, 1904, subsp. ?

A single male from Lalla Rookh Station, North-West Australia (W.A. Museum ; cf. Davis, 1940, p. 159, Figs. 5–6) is intermediate between *O. gurneyi spinulosa* and subspecies occupying a more easterly and northerly range (*O. gurneyi subclavata* Davis 1936, *op. cit.*, p. 240, Fig. 4 : North Australia ; and *O. gurneyi centralis* Davis 1936, *op. cit.*, p. 237, Fig. 2 : Central Australia). A male from Hermannsburg, Central Australia (Davis, 1940a, p. 157, Fig. 7) is barely distinguishable from the Lalla Rookh example, so that this series may have a wide range, and deserve subspecific nomenclature. The first segment of the left cereus is only barely clavate, as in *O. gurneyi subclavata* ; the left cereus-basipodite is blunt and more or less upcurved, suggestive of *O. gurneyi centralis*. The processes of the hemitergites, however, agree most closely with *O. gurneyi spinulosa*.

Further specimens are required, especially (1) from localities between the range of *O. gurneyi spinulosa* (supra) and the localities Lalla Rookh and

Hermannsburg ; and (2) from between these latter localities and the type regions of *O. gurneyi subclavata* and *O. gurneyi centralis* respectively. Until some extra records are obtained, it seems premature to name the Lalla Rookh example subspecifically.

## Family **NOTOLIGOTOMIDAE** Davis 1940b.

*Ann. Ent. Soc. America*, **33**, 4, p. 681. Type genus, *Notoligotoma* Davis 1936, *op. cit.*, p. 244.

Other genera included in this family are *Metoligotoma* Davis (Eastern Australia). *Ptilocerembia* Fried. (Java and Sumatra), *Embonycha* Navas (Indo-China), and the fossil *Burmitembia* Ckll. (Burmese Amber. ? Miocene). The family is thus Indo-Malayan in distribution ; the feature common to all its members is the reduction of the second segment of the left cercus in the adult male, and its fusion, to a greater or a less degree, with the first segment. In all genera where the character has been studied, there is a medial bladder on the plantar surface of the hind tarsus : this is common to both sexes and all stages.

### Genus **NOTOLIGOTOMA** Davis 1936.

*Loc. cit.* Genotype, *Oligotoma hardyi* Friederichs 1914, Rec. W.A. Museum, **1**, 3, p. 241.

Australian Notoligotomidae, *males* winged, or with winged and wingless forms in the same species ; $R_{4+5}$, M, and $Cu_{1a}$ simple, the first two well-developed ; cross-veins relatively frequent ; tenth abdominal tergite completely divided to hemitergites, separated basally by a trapezoidal median sclerite. Right hemitergite with a postero-median process and an inner process, stout and echinulate, curving forward from the anterior end of its inner margin. Inner margin of left hemitergite produced back to a long thin subacute process. First segment of left cercus clavate and echinulate, second less than twice as long as its average thickness, firmly set on the outer and distal part of the first segment and not movably articulated thereto. Left cercus-basipodite fused to left-hand margin of hypandrium, terminally produced to a subobtuse process.

*Both sexes* with two bladders on plantar surface of first segment of hind tarsus, one medial, the other terminal. (The medial bladder possibly indicates the position of the end of one segment, the basal segment thus being formed of two segments of an ancestral condition closely fused ; this view is supported by the fact that the medial bladder is present in all those genera which on other characters are regarded as primitive.)

**Notologotoma hardyi** (Friederichs, 1914) Davis, 1936 (Plate I., figs. 3–4, 17–19).

*Op. cit.*, p. 245. *Oligotoma hardyi* Friederichs, 1914, 1 c.

♂ *Length* 8.8–11.0 mm. ; head 1.5–1.8 mm., x 1.3–1.5 mm. ; forewing 7.9–10.9 mm., x 1.9–2.8 mm. ; hindwing 6.4–9.6 mm., x 1.8–2.7 mm. *Colour* rather pale brown, eyes and wings as in *Oligotoma*. *Head* with eyes prominent, posterior margin slightly incised laterally ; antennae with up to 19 segments, maximum total length 4.3 mm. ; mandibles (Plate I., fig. 19) with dentition as in *Oligotoma*, outer margin sinuous. *Thorax* including wings (Plate I., fig. 3) and legs (Plate I., fig. 4, hind tarsus) normal for the genus. *Terminalia* (Plate I., fig. 17) with right hemitergite produced inwards and backwards to a tapered process, weakly bifid terminally ; inner process hooked, weakly nodulose. Process of left hemitergite (Plate I., fig. 18) narrowest at origin, then slightly expanded, terminally tapered and subacute. Inner margin of

first segment of left cercus irregular and echinulate ; second segment short, subconical, firmly fused to first segment. Ninth abdominal sternite with a slender heavily-sclerotized finger-like process directed upwards ; left cercus-basipodite with a similar process directed backwards and to the left. Terminalia otherwise as throughout the genus.

♀ See Davis, 1936, p. 246.

*Localities :* Near Perth, coll. G. H. Hardy (Friederichs' types, no longer extant) ; Caversham, near Perth, vi/15, coll. C. Kerruish (♂♂, W.A. Museum, Macleay Museum, etc. ; *infra*) ; Midland, near Perth, vi/36 and vii/38 (♂♂) ; Cottesloe, 25/v/40 (4 ♂♂ ; new record).

In addition to these localities in Western Australia, the species is known from near Nyngan, N.S.W., and from near Townsville and Rockhampton, Q. (Davis, 1936, p. 246, and 1940a, p. 158).

*Note.*—It is clear that Friederichs' types have been lost. A male (slide mount ; Macleay Museum) has accordingly been designated neotype. The locality, Caversham, is as close to the original type locality as can be determined ; the specimen agrees with Friederichs' description in all respects.

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## KEY TO THE SPECIES OF WESTERN AUSTRALIAN EMBIOPTERA.

(Characters are for the adult male ; the tarsal features apply to both sexes and all stages.)

1. $R_4+_5$ and M well-defined ; first segment of hind tarsus with a medial bladder on the plantar surface ; first segment of left cercus echinulate, second segment of length less than twice average breadth, not distinctly articulated with first *Notoligotoma hardyi* (Fried).

   $R_{4+5}$ and M subobsolescent ; medial bladder of first segment of hind tarsus absent ; first segment of left cercus not echinulate ; second segment with length at least three times maximum breadth, and clearly and movably articulated with first segment 2

2. Process of left hemitergite with a terminal hook ... ... ... ... ... 3

   Process of left hemitergite with a lateral process ... ... ... ... ... 5

3. Terminal hook of process of left hemitergite projecting to both sides from point of attachment ; margin of ninth abdominal sternite minutely echinulate near right-hand distal angle ... ... ... ... ... *Oligotoma glauerti* Tillyard.

   Terminal hook of process of left hemitergite projecting only to the left from its point of attachment ; ninth abdominal sternite smooth ... ... ... ... ... 4

4. First segment of left cercus clavate ; left cercus-basipodite spinescent *Oligotoma gurneyi spinulosa* Davis.

   First segment of left cercus subcylindrical ; left cercus-basipodite blunt *Oligotoma gurneyi* Frogg., subsp. ?

5. Lateral lobe of process of left hemitergite blunt, spathulate ; outer process of right hemitergite terminally bidentate ; first segment of left cercus very markedly incurved terminally ... ... ... ... ... ... *Oligotoma tillyardi* Davis.

   Lateral lobe of process of left hemitergite a sharp, flat spine ; outer process of right hemitergite terminally tapered, obtuse ; first segment of left cercus only slightly incurved ... ... ... ... ... ... *Oligotoma approximans* Davis.

*Note.*—The exotic species *Oligotoma saundersii* Westwood (native of the Indian Region) and *O. humbertiana* (Sauss.) Davis (native of Ceylon) may later be found to occur in North-West Australia. The terminalia of each (cf. *e.g.*, Davis, 1939, Figs. 3, 5) are very distinctive ; the former has a curved spine arising subterminally from the left-hand margin of the ninth abdominal sternite, and curving under this and upwards on the right ; the latter has a prominent tooth on the outer margin of the outer process of the right hemitergite, this tooth being situated well forward of the termination of the main process.

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## EXPLANATION OF PLATE 1.

Figs. 1–2., *Oligotoma approximans* Davis, holotype ♂ : 1, right fore and hindwing, x 9, 2, hind tarsus viewed laterally, x 38.

Figs. 3–4., *Notoligotoma hardyi* (Fried.), neotype ♂ : 3, right forewing, x 9. 4, hind tarsus viewed laterally, x 38.

Figs. 5–7., *Oligotoma glauerti* Till., paratype ♂ : 5, terminalia from above, x 9. 6, process of left hemitergite of tenth abdominal segment, from above, x 38. 7, mandibles from above, x 60.

Figs. 8–10., *Oligotoma tillyardi* Davis, holotype ♂ : Corresponding structures and magnifications to Figs. 5–7.

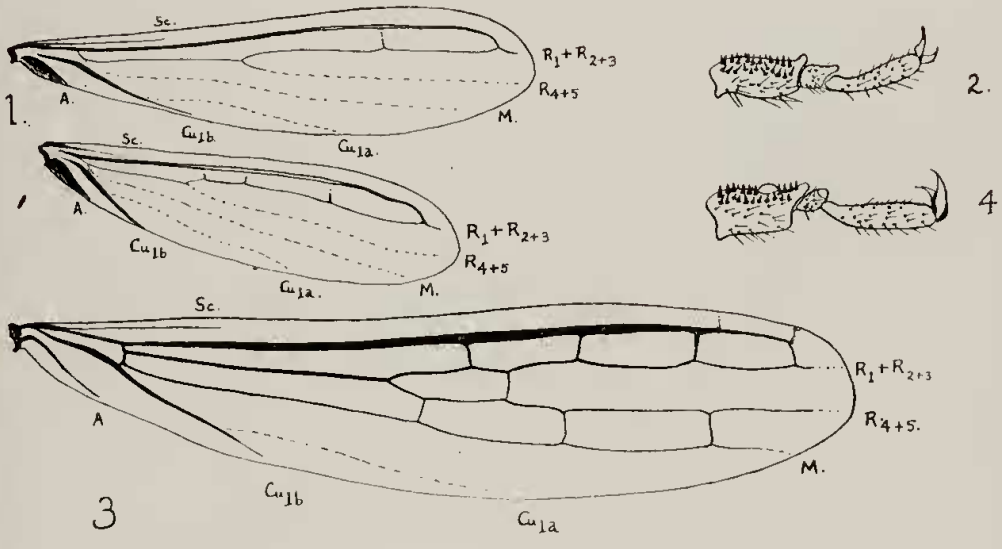
Figs. 11–13., *Oligotoma approximans* Davis, holotype ♂ : Corresponding structures and magnifications to Figs. 5–7.

Figs. 14–16., *Oligotoma gurneyi spinulosa* Davis, holotype ♂ : Corresponding structures and magnifications to Figs. 5–7. (First segment of left cercus slightly distorted on slide mount, Fig. 14, $LC_1$).

Figs. 17–19., *Notoligotoma hardyi* (Fried.), neotype ♂ : Corresponding structures and magnifications to Figs. 5-7.

(All figures prepared with a projection drawing apparatus, or based on camera lucida outlines. Setae omitted except in Figs. 2 and 4.)

9, ninth abdominal tergite ; 10L, 10R, left and right hemitergites of tenth abdominal segment ; $LC_1$, $LC_2$, $RC_1$, $RC_2$, first and second segments of left and right cerci respectively).



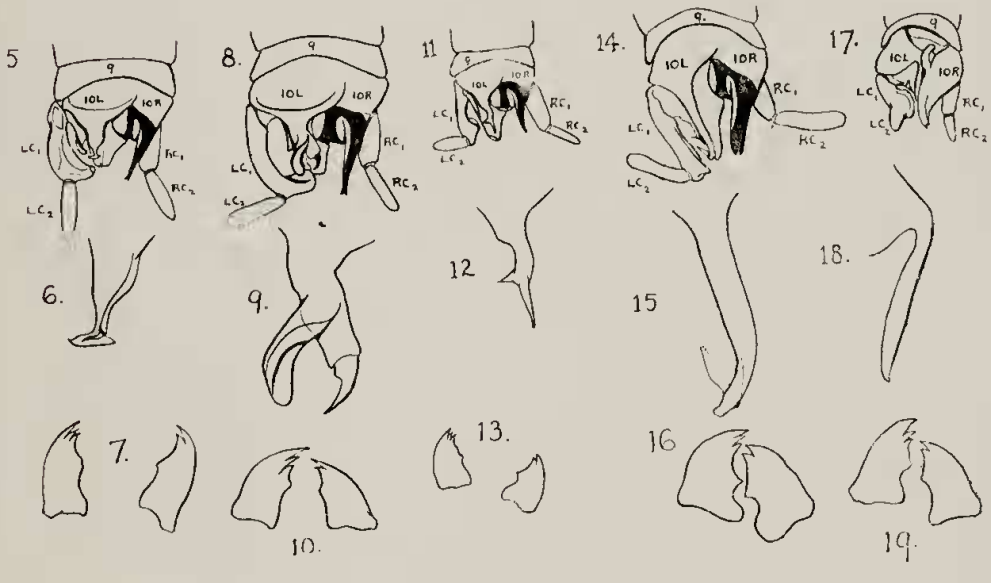




PLATE I.

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